PETROLOGY AND COMPOSITION OF HED POLYMICT BRECCIAS.

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Introduction: The howardite, eucrite and diogenite (HED) clan of meteorites forms the largest suite of achondrites with over 900 named members. The HEDs are igneous rocks and breccias of igneous rocks from a differentiated asteroid [1]. The consensus view is that these rocks hail from the asteroid 4 Vesta, which will be the first target of NASA's Dawn mission. When Dawn arrives at Vesta, she will begin remote imagery and spectroscopy of the surface. The surface she will observe will be dominated by rocks and soils mixed through impact gardening. To help with the interpretation of the remotely sensed data, we have begun a project on the petrologic and compositional study of a suite of HED polymict breccias. Here we report on the preliminary findings of this project.

Samples and Methods: We have obtained thin sections and chips 2-5 grams in mass from 30 HED polymict breccias from the US Antarctic collection. Of these, 27 are classified as howardites and the rest as polymict eucrites. We have also studied a thin section of LEW 87002 which is classified as a Mg-rich eucrite. This meteorite has recently been described as a howardite [2]. Petrographic and mineralogical study has been done by optical microscopy, scanning electron microscopy (SEM) and electron microprobe analysis (EMPA). Chemical analyses are underway. Major element compositions will be determined by X-ray fluorescence spectrometry (XRF) on splits of homogenized powders. For the purposes of this abstract, we will use literature compositional data as available.

Petrography: Among the howardites, there is considerable variation in matrix texture, clast size and abundance, and clast petrologic type. EET 87503 and MET 00423 contain numerous mafic (eucritic) clasts up to several mm in size with basaltic to gabbroic textures (Fig. 1). Orthopyroxene (diogenite) clasts are subordinate and smaller. Melt-matrix breccia clasts are present in both. Glassy material is uncommon, although EET 87503 does contain glassy-matrix breccia clasts.

In contrast, in QUE 94200 eucritic clasts are mostly smaller in size and subordinate to diogenitic clasts. This meteorite contains numerous melt-matrix and glassy-matrix breccia clasts and a portion of a large glassy spherule containing low-Ca pyroxene phenocrysts (Fig. 2).

Chondritic clasts are common components in howardites and polymict eucrites, and these are generally CM or CR chondrites [3]. We have tentatively identified only one chondritc clast in our thin section set, but have not yet done detailed study of it. Although small black clasts are common in our thin sections, these are mostly either glassy-matrix breccia clasts or troilite-rich clasts [*c.f.* 4].

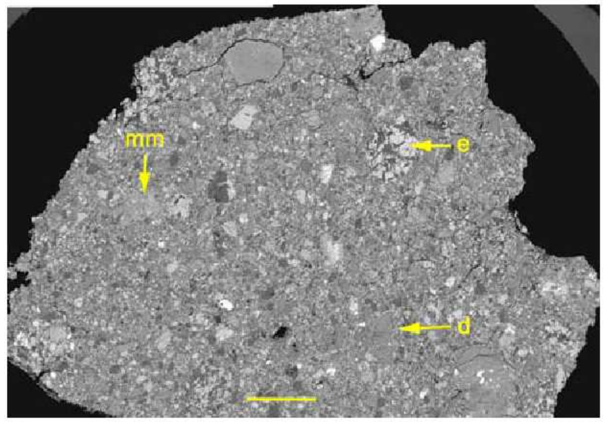

Figure 1. Backscattered electron (BSE) image of EET 87503. Labels: d – diogenitic clast; e - eucritic clast; mm – melt matrix clast. Scale bar is 2 mm.

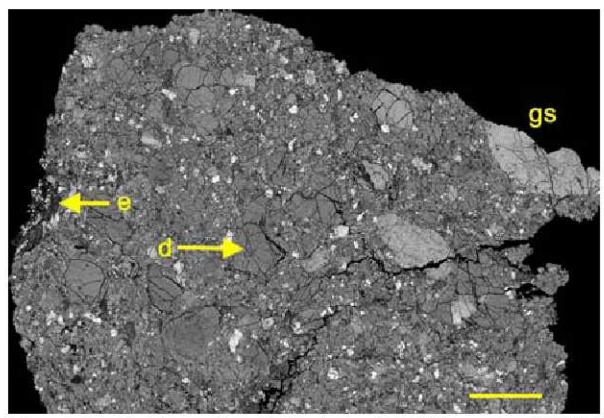

Figure 2. Backscattered electron (BSE) image of QUE 94200. Labels: d – diogenitic clast; e – eucritic clast; gs – glassy spherule fragment. Scale bar is 2 mm.

Composition: Based on literature data, the polymict breccias studied here exhibit a wide range in eucrite/diogenite mixing ratios. Among HED igneous rocks, eucrites are much richer in Al than are diogenites, while the opposite is true for Mg. A diagram of Al vs. Mg thus can be used to infer mixing ratios for HED polymict breccias. Figure 3 is such a plot based on averages of literature data. For the howardites under study here for which literature data are available,

the Al contents vary from 61 to 28 mg/g, indicating a wide range in eucrite/diogenite mixing ratio.

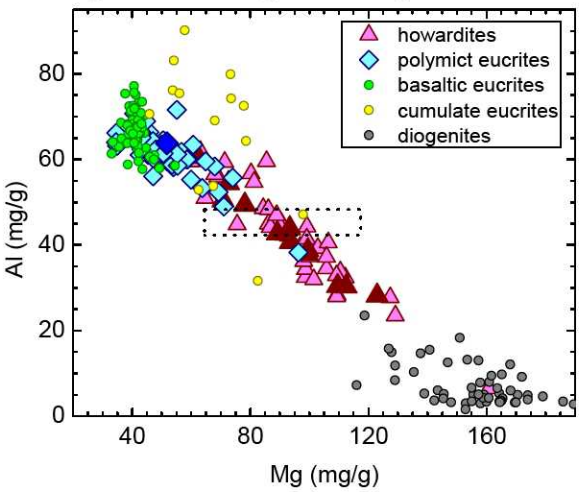

Figure 3. Al vs. Mg for HED meteorites from averaged literature data. Larger, darker symbols for some polymict breccias are for meteorites under study here. The box shows the range of Al contents found for those howardites classified as regolithic by [2].

Discussion: Warren *et al.* [2] have identified a subset of howardites with a limited range in Al contents (42-48 mg/g) that also have high Ni and noble gas contents. Siderophile elements such as Ni are low in the igneous lithologies of the vestan crust. High siderophile element contents are considered to represent contamination by mixing chondritic projectile material into the surface breccias. Similarly, the noble gas abundances in eucrites and diogenites are low. Their enhancement in HED polymict breccias can come from two sources – solar wind implanted gases on soil particles exposed at the surface, and as planetary-type noble gases contained in chondritic debris. Warren *et al.* [2] have posited that the confluence of limited range in Al, high Ni and high noble gases indicate that these howardites represent a well homogenized ancient regolith and refer to them as regolithic howardites. Other howardites represent more recent polymict breccias and are not true regoliths in the sense of having been part of an extensively impact-gardened surface layer on Vesta.

As part of our project, we will test this hypothesis by doing detailed petrographic observations on chemically well-characterized samples of a range of HED polymict breccias. For this poster, we will examine the relationships between petrography and major elements. Future work will include trace and siderophile element determinations on splits of the samples, and noble gas analyses on separate chips split off the sample before grinding and homogenization.

References: [1] Mittlefehldt D.W. *et al.* (1998) *Rev. in Mineral., 36,* chapt. 4. [2] Warren P. H. *et al.* (2009) *Geochim. Cosmochim Acta, 73,* 5918. [3] Zolensky M. E. *et al.* (1996) *Meteoritics Planet. Sci. 31,* 518. [4] Fuhrman M. and Papike J. J. (1981) *Proc. Lunar Planet. Sci. Conf. 12,* 1257.